World Ocean Circulation Experiment

NEWSLETTER

Number 12 February 1992

FEATURES

1991: A PRETTY GOOD YEAR FOR WOCE

Activity within each of the WOCE sub-programmes intensified significantly during 1991 and will continue to do so during the 1992 to 1994 period, the heart of the WOCE field programme. A major event expected in 1992 is the launching of TOPEX/POSEIDON in July. Simultaneously, the *in-situ* programmes will double that of 1991. While there is much to be encouraged by, there still remains several critical programme gaps. They are described elsewhere in this Newsletter.

Some of the 1991 highlights were:

- **ERS-1 launched in July,**
- **9 current meter arrays deployed,**
- **84 floats deployed,**
- **Nearly 500 WOCE/TOGA drifters deployed,**
- **WHP one-time survey lines A1E, A9, P16N&C, P17 and 9 supplementals completed,**
- **35 occupations of WHP repeat lines,**
- **XBT coverage expanded,**
- **CP3 Control Volume III and Subduction, Deep Basin and Tracer Release Experiments began,**
- **Mooring, Float, Upper Ocean Thermal, Sea Level (Bidston) and Drifter Data Assembly Centres (DACs) began operation,**
- **Fine Resolution Antarctic Model (FRAM) runs completed, Atlas published.**

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WOCE PRIORITIES AND MAJOR PROGRAMME GAPS

The development of priorities and finding solutions to critical resource needs continually face all participants in WOCE. The SSG has spent a great deal of time over the past year addressing priorities and gaps and has produced a general priority statement that can be used by scientists, institutions and nations for guidance in planning their involvement and support for WOCE over the long term. The SSG has also identified specific major programme gaps which need urgent attention. The latter will be submitted in March 1992 to the Intergovernmental WOCE Panel, whose primary function is to address means of providing those resources required to meet WOCE needs. In addition to that somewhat limited formal approach, the SSG hopes the wider community of PIs and agencies will take these recommendations into consideration when determining their individual priorities or allocating resources. The general priorities and specific major gaps are given below. The latter identify the issue, what WOCE is doing about it and how National agencies can help.

WOCE SSG STATEMENT ON PROGRAMME PRIORITIES APPROVED AT WOCE-17

At WOCE-17, Wormley, 20-22 November 1991, the SSG evaluated the status of committed resources to the planned WOCE field and modelling programmes. The scope and timing of the commitments that are now firm has led to a re-assessment of programme scheduling. It is clear that many important WOCE objectives will not fully be met unless firm commitments by nations remain firm, commitments that are now tentative are strengthened and additional resources are found. The SSG has evaluated programme objectives and timing as noted below, with first priority being given to establishing on a systematic basis the required global coverage.

<u>Global Survey</u>

Hydrographic Programme

Given the timing of commitments for the WOCE Hydrographic Programme, the WHP is initially concentrated in the S. Pacific and S. Atlantic, and will move its major concentration of effort to the northern oceans and Indian Ocean later. The data requirements for modelling suggest that collecting a basin-scale data set in each ocean over a limited time period is essential. Moving the concentration of effort from basin to basin (but with overlap in coverage) will allow collection of such data in a time of limited resources. This needs to be coincident with the collection of data within the basin from floats and drifters, which require five years of data, as well as from moored arrays and other systems.

This basin-by-basin (with overlap) approach, given existing commitments, means that the intensive field programme period will of necessity be seven years, 1990-1997, longer than the five years originally proposed. Further lengthening of this period would lead to the failure to meet some WOCE objectives. Thus, the commitments needed to implement WOCE are required within this seven year time frame.

Oceanic Heat Flux

The SSG puts high priority on the need for global heat flux measurements. This requires at least one zonal "heat flux" section in each ocean basin including current meter arrays at each end of the hydrographic section. Nations are asked to make their commitments to these arrays firm and secure.

All sections of the one-time WHP survey are required for determination of the global heat transport. The SSG emphasizes the importance of complete (coast-to-coast) hydrographic sections and discourages partial lines. No partial lines will be designated as meeting WOCE requirements unless specifically approved by the Core Project Working Groups.

The SSG also emphasizes the priority of the Southern Ocean "choke point" sections where the transport of heat and mass can be measured between the ocean basins. The final design of these sections and commitments to their implementation needs to be pursued.

Mid-depth Floats

Technological developments for the float programme have been successfully completed. The SSG noted the importance of focussing float releases on a single deep level, and of having an adequate number of floats in any one basin to directly measure the flow at that level.

Current commitments of floats permit the start of a basin-by-basin deployment. However, additional commitments are required if global coverage meeting WOCE goals is to be obtained. Elsewhere, there are not adequate commitments of floats for the required enhancement of the global coverage. At the equator this enhancement calls for floats at different levels and in the Atlantic for better spatial resolution of the global coverage at the deep reference level.

Moored Current Measurements

The commitments for current meter arrays are not strong. The SSG urges that first priority be given to the moorings for the heat flux sections in each ocean basin and for the Southern Ocean choke point sections. Next priority should be given to those arrays that define the transport of water masses through major topographic features.

Surface Layer Programme

Measurements are required throughout WOCE of the evolution of the upper ocean and its surface forcing through the fluxes of momentum, heat and fresh water. The VOS low density XBT and surface drifter programmes which approach adequate coverage in the northern hemisphere, support this effort. In the case of limited commitments, these programmes should give priority to continuing coverage in regions where it is now adequate.

Time and Space-Dependence: Defining Variability

Global Measurements

The SSG recognizes the need for temporal data and emphasizes the importance of repeat hydrography (subscribed at the 70% level now). In this context, SSG also emphasizes the need for high resolution XBT sections to estimate variability of the circulation, especially near heat flux and choke point sections. Continuation of XBT sections that have been taken over closely-repeated tracks is also given priority. Few time series stations are now committed. Because time series data are most useful after decades of data has been collected, WOCE encourages the continuation of existing stations and secondly the establishment of new ones.

Critical Tests of Models: Core Project 3

Higher resolution in both space and time is the objective of the basin- and gyre-scale measurements of Core Project 3. The importance of such information in determining the response of the ocean to seasonal and interannual changes in surface forcing is becoming increasingly evident. It is essential for the development of coupled ocean/atmosphere models for the prediction of climate change and the definition of ocean data required for their initialization.

Given the present basin by basin approach of the global programme, the SSG gives priority to the development of Core Project 3 in the North Atlantic later in WOCE (1993-1997). Special attention needs to be given to enhanced basin-scale measurements using floats and drifters as well as to measurements of the spatial and temporal variability of both the surface forcing and the full-depth oceanic response using repeat hydrography, VOS measurements and a variety of moored and shipborne instrumentation. The success of this programme would be greatly enhanced by completing the one-time WHP lines in the Atlantic within as short a time as feasible during the same period.

The components of the basin- and gyre-scale Core Project 3 field programme remain seriously under-committed. Substantial resources are required in addition to those already committed to the Deep Basin Experiment, the Subduction Experiment, the Tracer Release Experiment and to other experiments (within and outside WOCE) being undertaken earlier.

Satellite Measurements

The success of WOCE depends on global measurements, and satellites are required for this purpose. WOCE has been designed to take full advantage of satellite measurements of surface wind stress by scatterometer and surface topography by altimeter. It is essential to WOCE that such satellite measurements continue throughout the WOCE field programme. Thus, the SSG fully endorse and support ERS-1 and its continuation ERS-2 for altimeter and scatterometer measurements, TOPEX/POSEIDON for precision altimeter measurements and NSCAT on ADEOS for precision scatterometer measurements. The SSG supports measurements of the earth's radiation balance by satellite since they provide the overall context for the ocean heat flux within the climate system. Inference of mean currents requires both surface topography and the geoid. The geoid over the ocean can only be measured by satellite but no such satellite mission is proposed. Thus, the SSG endorses a new gravity mission, such as the ARISTOTELES mission being discussed.

The SSG also notes the continuing requirement for satellite altimeters and scatterometers for climate research. Monitoring and prediction beyond the WOCE intensive observation period.

Modelling

The development of models for the prediction of climate change is the primary goal of WOCE. The SSG emphasizes that models need good data sets to test them and that a close interaction between modellers and observations needs to be maintained. Noting the importance of coupled models for climate prediction, the SSG encourages national and international institutes to strengthen ocean and coupled ocean-atmosphere modelling and the comparison of models with observations. This needs to be in addition to the present climate modelling effort.

The SSG emphasizes the need for significant investment in people and computer power well before the end of the WOCE intensive field period, and that data assimilation techniques need to be further developed in preparation for the WOCE data sets.

The SSG recognizes that resource problems vary from country to country (people, money, facilities), but emphasizes the importance of modelling as a central element of WOCE. Without substantial advances in modelling, WOCE will not meet its major objectives.

Technology Development and Transfer

There remain a number of instrumentation developments that are required for WOCE to fulfil its goals and/or increase the field programme's efficiency. These developments need to progress beyond prototypes used by individual scientists to tools available to the wider community. The SSG supports developments to increase the lifetime of subsurface floats, enable their use under ice and the coupling of "continuous" tracking and satellite reporting; to provide reliable sea-surface atmospheric pressure from surface drifters and to increase their lifetime and/or improve their cost per year of use; and to enable the measurement of continuous sea-surface salinity and salinity profiles in the upper ocean. The development of the fast fish into an operational instrument could lead to its effective use during WOCE to augment hydrographic measurements.

The SSG also supports the development of other instrumentation which, although it may not be available in time to help meet WOCE objectives, will be required to support long-term ocean climate observing systems. In this category one can presently identify autonomous profiling vehicles, long-range tomography for integrated measurements of ocean properties and better ocean data telemetry systems.

MAJOR WOCE PROGRAMME GAPS

Southern Ocean Choke Point Sections

What is the issue

Measurement of the Antarctic Circumpolar Current through the three "choke point" sections (in Drake Passage and south of South Africa and Australia) is a major element of WOCE and Core Project 2. It is the Antarctic Circumpolar Current that links the circulation of the Pacific, Indian and Atlantic Oceans and transforms the oceanic heat flux from a regional to a global phenomenon. The SSG has given the same priority to measurements at the "choke point" sections as at the heat flux sections in each ocean basin.

Obtaining accurate fluxes through the "choke point" sections is a difficult problem that can only be addressed by a concerted effort using a suite of instruments. While some support has been provided by nations, there is a need for additional selected commitments in order for the programme to be effective. These commitments are required for field programmes and equipment during the next 3 years in order to allow co-ordination with commitments already made and to provide needed simultaneity of measurements at all three "choke point" sections and with, to the extent possible, WHP sections in the Southern Ocean.

What is WOCE doing about it

A working group met in the fall of 1990 to plan the measurements on the "choke point" sections. Commitments were assessed and a strategy proposed that would enable an effective if not optimal programme to be put in place. It was noted that although pressure gauges are to be deployed for 4 years starting during the 1991-92 austral summer across all the "choke point" sections, none of the required repeat hydrography has been committed for Drake Passage. In addition, the working group noted that commitments to the direct velocity measurements specified in the Implementation Plan are minimal, and limited to the section south of Australia, although additional measurements are being planned in the gap between the Crozet and Kerguelen Plateaux. The Working Group recognized the need for additional commitments for current meter moorings and recommended that they be concentrated on the section south of Australia in order to obtain the best estimate possible of the total flow on at least one of the "choke point" sections.

How can National Agencies help

Nations are asked to make commitments for 4 sections across Drake Passage using a ship with an ADCP before the 1995-1996 austral Summer. Additional commitments are sought for current meter moorings to be co-ordinated with those already committed and deployed on the section south of Australia by early 1993.

Core Project 3

What is the issue

Core Project 3 is that part of WOCE that will study one ocean basin in sufficient detail that it will be possible to make major advances in models for that ocean basin that can be extended to models of the global ocean. It was developed with the recognition that the global measurements of Core Projects 1 and 2 will be unable to resolve the details of the basin- and gyre-scale variations of the deep ocean circulation with time scales of weeks to years and to relate those variations to changes in the surface forcing. The gyre- and basin-scale measurements of Core Project 3 are therefore essential to the fulfilment of the primary goal of WOCE to "develop models for the prediction of climate change and to collect the data to test them".

Recent consideration has been given to the design of ocean observing systems for the collection of data for the initialization of models for the prediction of climate change. Through TOGA an understanding is being developed as to the data set which is necessary for ENSO prediction. The basin- and gyre-scale measurements of Core Project 3 are essential if WOCE is to provide an understanding of the sensitivity of the coupled ocean-atmosphere system to changes in the full-depth ocean circulation at all latitudes. An assessment of the extent to which inter-decadal climate change is predictable and the design of a full global ocean observing system for climate prediction await this understanding.

The field components of the basin- and gyre-scale components of Core Project 3 remain seriously under-committed. Substantial resources are required in addition to those already committed to the Deep Basin Experiment, the Subduction Experiment, the Tracer Release Experiment and to other research being carried out at present.

What is WOCE doing about it

The Core Project 3 Working Group has re-examined the experimental design of the basin- and gyre-scale measurements as proposed in the Implementation Plan and found the approach to be basically sound. Some suggestions are being examined that would allow alternate combinations of standard instrumentation to measure temporal changes of the full depth circulation. The requirements for floats, drifters and the VOS XBT programme remain unchanged.

When setting the priorities for WOCE and the co-ordination of Core Project 3 with Core Project 1, the SSG has emphasized the importance of pursuing the basin- and gyre-scale measurements of Core Project 3 in the North Atlantic in the period 1993-97.

How can National Agencies help

Nations are requested to make a commitment to find resources to carry out the basin- and gyre-scale measurements during the period 1993-97. It should be noted that some elements of the programme, for example VOS lines, can be carried out by coastal nations using limited resources. Time series measurements should be started as soon as possible.

High Density XBT Sections

What is the issue

XBT programmes from merchant vessels traditionally provide a sparse sampling of the oceanic upper thermal field. In the North Pacific and the tropical Pacific and Atlantic oceans, they provide monthly and bimonthly information on the extent and structure of thermal anomalies. When coupled with estimates of winds, air sea fluxes and SST, they form the basis of the operational models currently being run in the tropical Atlantic and Pacific Ocean. Such observations typically involve the officer of the watch launching an XBT from the bridge two to four times each day.

Sixteen to twenty launches/day are required if one wishes to estimate the volume and heat transport through a section. This level of activity generally requires an assigned technician on the vessel. These programmes are more expensive to operate, both in terms of probes and also in terms of personnel salary and travel costs. Such sections also require the active participation of a scientist in order to carry out the analysis from a temperature section to a mass and heat transport estimate.

WOCE has designed a high density XBT sections network in the Pacific which, together with the repeat hydrography, satellite altimetry, surface drifters and mid depth floats should describe the seasonal and interannual variability of its circulation. These should be occupied at least four times each year over several years to allow a seasonal signal to appear out of the mesoscale and interannual signals.

High density XBT sections are also required for the meridional heat flux sections in the Atlantic and Indian Oceans and of the choke point sections in the Southern Ocean. These sections should be occupied at least four times throughout the year; preferable during the period that moored instruments are measuring the major current systems through the section.

What is WOCE doing about it

Groups in Australia and the US have started or are committed to starting high density XBT sections. By 1993, the high density XBT network in the northern and southwestern Pacific will be largely in place although most sections are to be occupied only twice/year rather than the four or more times that is really required. Similarly, groups are prepared to start the Atlantic.

An automatic carousel has been developed by Scripps to permit a number of probes to be launched sequentially from the stern of a vessel by remote command from the bridge; however the carousel still needs to be reloaded one or more times each day. Fewer probes are lost through breakage of the wire when launched from the stern; this system may be useful for conventional XBT programmes as well.

How can National Agencies help

Existing groups need greater resources or we need two or three more nations or groups to begin to do this type of work. Our particular needs on various lines are as follows:

Atlantic

AX7, AX16: US to start high density in 1992 but frequency not yet known. The priority in 1992 should be to get 4 occupations of AX16. AX7 will have its highest priority in the 93-95 time frame. Without this frequency of repeats we will have little information of the variability of the heat and mass transport associated with the entire subtropical gyres of the North and South Atlantic.

Indian

IX2 or IX21, IX15: Priority time frame is in 1994-96 when moorings and the rest of the Indian Ocean hydrography is being done. Need at least 4 occupations throughout the year to estimate the variability within a year of the heat and mass transport between the Indian and Southern oceans.

Pacific

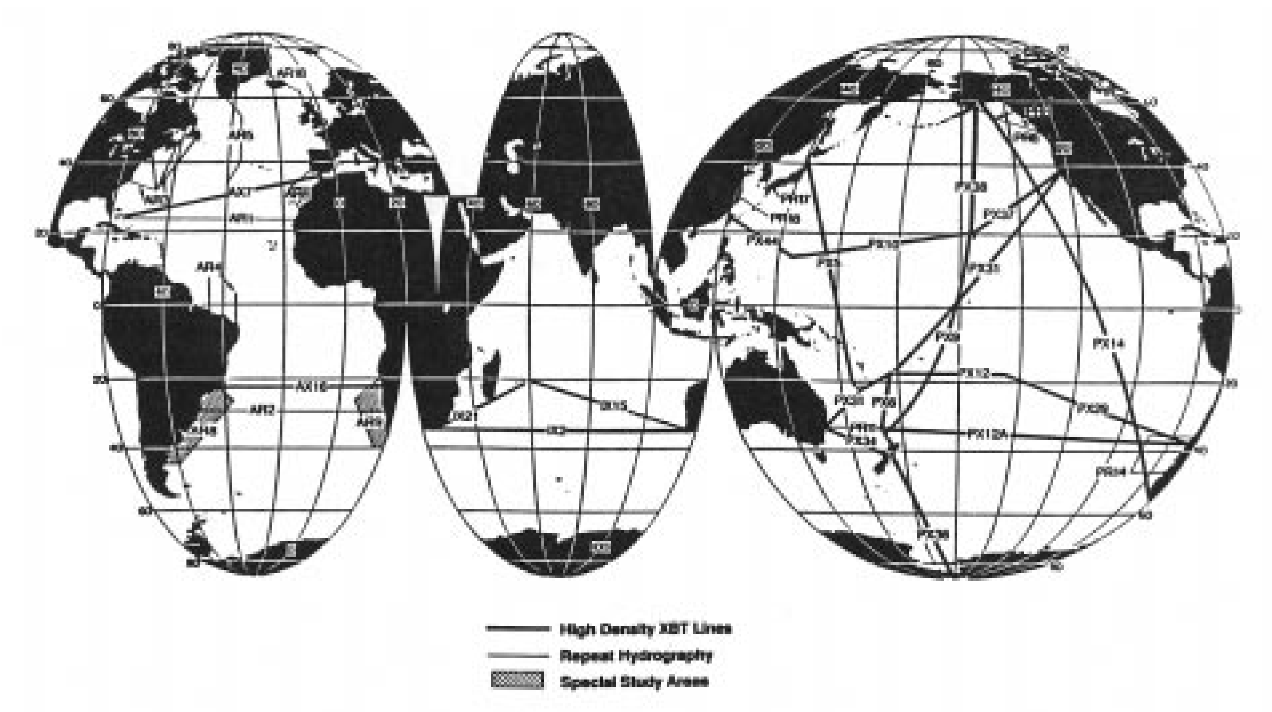
PX12A or PX12, PX29: Require 4 repeats of this heat flux section in the 92-95 time frame. Prefer a routing that remains in the latitude band 25 to 40°S. No HD commitment at present for this work, its lack will mean that we will have no estimates of the seasonal variability of the heat and mass exchange between the Pacific and the Southern oceans.

PX14: No commitments for HD sampling along this section. Without this section, we will not be able to estimate the variability of the heat and mass transport into and out of the eastern boundary regions. This information is required for an assessment of the role that eastern boundary processes might play on the structure of the upper ocean.

PX5, PX10, PX37, PX38, PX44: Require the additional resources to increase the sampling of these sections to 4 times/year. It is difficult to see how one can estimate the variability of the circulation of an entire ocean if some parts are sampled twice a year and others four times/year. Our experience with model simulations in the Atlantic suggests that quarterly sampling is the minimum required.

Southern

PX36: Require an Antarctic scientist to try the technique on this section between New Zealand and Antarctica to determine whether it can provide an estimate of the transports in the circumpolar current systems. Will need probes every 10 - 15 miles and an Acoustic Doppler Current profiler because of the large barotropic component and small horizontal scales of the current structure.



World Chart of High Density XBT sections and Repeat Hydrographic sections required at least quarterly

South Pacific WHP Lines

What is the issue

The southern ends of the meridional lines in the Pacific are an important element of WOCE and Core Project 2 because they connect the interior of the Pacific with the southern boundary of the WOCE one-time survey which is defined by the zonal section along 65°S (S4). These sections cross the Antarctic Circumpolar Current (ACC) and extent into the gyres south of the ACC. They define the circulation of the ACC which links the Pacific, Indian and Atlantic Oceans and contribute to the understanding of the pathways and northward flux of Antarctic Bottom Water.

Understanding of the dynamics of the ACC and the regions south of it requires the completion of all lines of the Pacific one-time survey to a latitude of at least 65°S (the latitude of the zonal S4 section). Presently, only the eastern sections are planned to be extended far enough south to intersect with S4. There are presently no commitments for the southern ends of the WHP lines in the western Pacific (P14, P15). This gap leads to serious problems in the understanding of the circulation in the southern Pacific, especially in view of the fact that only few high quality hydrographic data and basically no tracer data exist for this region from previous studies.

What is WOCE doing about it

The importance of the southern ends of the Pacific lines for the interpretation of the Pacific hydrographic and tracer data was pointed out by the Core Project 2 Working Group and by the Geochemical Tracer Scientific Panel. The SSG has given high priority to these measurements. The USSR and USA are co-operating to complete S4(Pacific) in 1992. They have been requested to consider utilizing any extra time to occupy P14S.

How can National Agencies help

Nations are asked to make commitments for the unsubscribed lines in the western South Pacific (P14 and P15) and to extent their commitments for the sections in the eastern Pacific to latitudes as far south as possible, but at least to the latitude of S4 (about 65°S). WOCE requirements would be met best using ice-breakers that could do sections into the Antarctic Coast.

Western and North Pacific WHP Lines

What is the issue

A key element of WOCE Core Project 1 and 2, is the occupation of a set of trans oceanic, eddy resolving, full depth hydrographic/tracer sections throughout the global ocean to modern analytical standards. This data set will provide a description of the present state of the three dimensional ocean circulation and form the basis of the ocean climate models that are to be developed over the next decade. If we are to achieve a uniform global description, it is essential that the sampling standards be maintained on all WHP one time survey lines.

There are, at present, serious shortfalls in the commitments to WHP sections in the western and northern North Pacific. According to our present information, the ship time scheduled for some sections is inadequate to allow the required (30 nm) station spacing to be achieved. The institutions and/or vessels committed to these sections are also lacking a rosette capable of carrying the 10 litre bottles as required for the small volume tracer programme. The problem is further compounded by the fact that few nations running sections have tracer laboratories that would produce the measurements.

The sections for which there are serious concerns are: P1, P2, P8, P9, P11N, P25, P26, P27, P28, P29 and P30.

If nothing is done to improve the situation, our knowledge of the circulation of the North Pacific at the end of WOCE will be significantly less than that of the rest of the world ocean. Given the size of this ocean basin, this will clearly reduce our ability to model the global ocean for climate purposes. Because work has already started in the Pacific, it would be most valuable if these improvements could be made and the sections run in 1993 or 1994.

What is WOCE doing about it

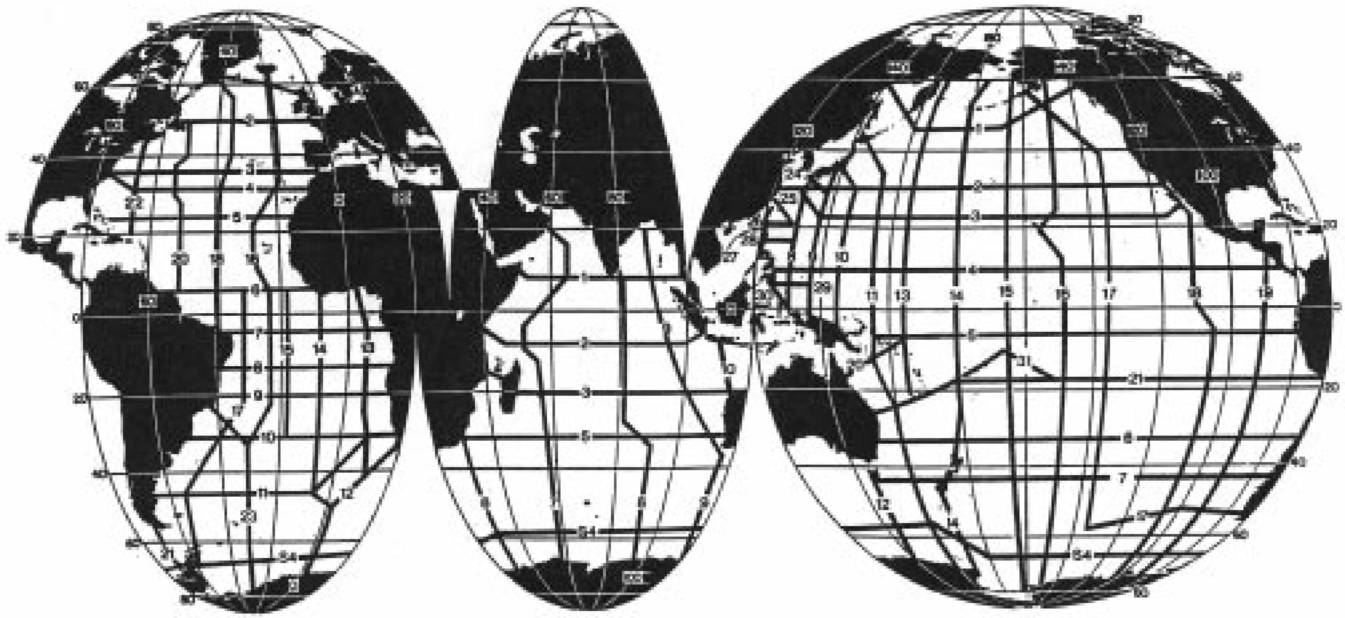
The WHP Office is continuing to collect information concerning the capabilities of the vessels and institutions that are planning to carry out these sections. It has informed nations and institutions about their deficiencies. It has produced documents and manuals outlining the required standards. It has participated in regional meetings in which it has urged the nations and institutions to look for means to solve these problems co-operatively.

How can National Agencies help

First, national agencies should see if they can find the resources to provide the necessary equipment or ship time to allow their scientific teams, or scientific teams from other nations, to meet WHP standards on these sections.

Second, national agencies could come together to jointly fund and train a team that could provide the necessary rosette and analytical capacity for several of these sections.

If the resources could be made available for the necessary equipment, WOCE would be able to assist in making arrangements for the necessary training. Resources such as berths on cruises, travel and living support in foreign institutions or travel and living support for trainers would be required from national or international agencies.



Distribution of WOCE One-Time Survey Lines

Intermediate Depth Floats

What is the issue

The intermediate depth float programme is considered to be one of the high priority components of WOCE. This is the case both globally, Core Project 1, and in the Atlantic, Core Project 3. These floats will provide a unique set of measurements that can be used to provide a reference level to give total transport from hydrographic data, and define the spatial distribution of eddy kinetic energy and eddy diffusion.

According to latest estimates, 70-75% subscription of the global Core 1 coverage is expected. This estimate includes previous SOFAR float deployments in the North Atlantic which contain data taken from 1972 to 1988. A large fraction of this total are either proposed, but not yet funded, or intended work. The coverage for Core 3 in the Atlantic falls well short (30-50%) of that required. Although there is interest in the scientific community to obtain the necessary float coverage, the financial support is not secure.

What is WOCE doing about it

Two types of floats, ALACE and RAFOS floats, are being used to make these WOCE measurements. The ALACE float has made the transition from prototype to an operational instrument, so that it can be used by groups other than at the Scripps Institution of Oceanography where it was first developed. Similarly there is now a version of the RAFOS float developed for use in WOCE that is available from commercial sources. Initial ALACE float deployments in the South Atlantic (January 1990) and Eastern Pacific (1991) are performing well.

How can National Agencies help

Given the maturation of the float technology, National agencies are urged to find support and to recruit participation of institutions and float groups in float work to achieve the necessary coverage. The immediate priority is to support the CP1 global coverage. Emphasis should be given to support for Atlantic CP3 studies starting in 1994.

Staffing of WOCE Facilities

What is the issue

The infrastructure established to carry out the planning and implementation of WOCE consists of the Scientific Steering Group (SSG) and its technical committees and operational units. The latter include the International Project Office (IPO), the Hydrographic Programme Office (WHPO), Data Information Unit (DIU), and Data Assembly (DAC) and Special Analysis (SAC) Centers. These units require various levels of staffing and overall require a minimum of 30 Full-Time Equivalent (FTE) posts. At present the manning level is 23 FTEs. The staff shortages are, however, concentrated in a few critical areas. They are: the WHPO, IPO and Indian Ocean Upper Ocean Thermal (UOT) DAC. Those facilities operating at present at sufficient levels are: Drifter, Mooring, Atlantic and Pacific UOT and Float DACs, the WHP SAC and the DIU.

In addition to its permanent staff, the WHP Office utilizes Data Quality Experts (DQEs) to assist in its data quality assessments. DQEs are scientists knowledgeable and interested in a specific data type or region who assist in ensuring that the data are achieving the quality standards set for the WHP. These experts are expected to review both the one-time survey and repeat hydrography data. For example, IPO expects that data sets from 39 Atlantic repeats will require DQE review by the end of 1992. Thus far, the availability of DQEs to assist WHPO for repeat hydrography is nil.

In view of the length of the WOCE planning and implementation phases (almost two decades), there is a continuing need for new, or replacement staff. Scientists recruited for these tasks have given up valuable research time but cannot be expected to give up careers. Recruitment is therefore an on-going task faced at all levels and must be kept in mind at all times by Nations when considering out-year funding.

What is WOCE doing about it

With the support of Nations and IOC, the SSG has been able to put the basic operational infrastructure in place. All offices and centers are operating at some level. The commitment of Nations to the infrastructure includes personnel and facilities. The IPO has issued vacancy announcements and SSG has worked directly with Nations to obtain secondments. The IOC has negotiated with Nations as appropriate to solicit commitments. The WHP Planning Committee is assisting the WHPO in obtaining the necessary DQE support.

How can National Agencies help

Nations are requested to support the staffing of the WOCE infrastructure in one of several ways. They are: by seconding fully funded persons to the international offices; providing funds (full or partial) to support persons available but not funded; and identifying qualified persons available without funding. The most urgent needs at the moment are to fully staff the WHPO, IPO and the Indian Ocean UOT/DAC in Australia.

Nations are requested to include support of WHP quality assessments by DQEs in their programmes. Two months of effort per year per expert is required for the latter. The WHPO is seeking 10 additional DQEs.

Contingency Funding for WOCE

What is the issue

International WOCE is running a global programme involving tens of different research groups and organizations in nearly as many countries with its own resources as well as those of the national agencies directed towards particular preplanned research grants, projects, cruises, meetings, etc. As the field work is being implemented, international WOCE is being approached increasingly by principal investigators and its own WOCE committees with problems requiring a few thousands to a few tens of thousands of dollars to solve. Often these problems are related to a particular cruise or situation and if not resolved within a period of a few months then a cruise goes to sea missing a key measurement or instrument or without necessary training, etc.

IOC and other international agencies have programmes for development and assistance; however, these are designed to build up a nation's capability over several years. They have been and will continue to be an excellent mechanism to provide the long term facilities in coastal states such as sea level and time series stations and support for XBT programmes.

What is WOCE doing about it

WOCE has already dealt with a number of such problems on an *ad hoc* basis. Some successful examples are as follows:

(1) Soviets provided port costs for Ioffe by USA.
(2) Travel, freight and direct costs of two nutrient chemists to participate in German South Atlantic WHP cruise.
(3) Funding for Standard Seawater Lecture associated with Vernadsky WOCE intercomparison/training provided by IOC and WHOI.
(4) Monitor placed on a Soviet vessel by Canada to restore computing environment.
(5) IPO has provided interim funding for communications (telemail) to allow individuals to participate more fully in WOCE implementation.
(6) Purchase of special flasks by US/PMEL for shipping gas for CFC intercalibration.

A number of situations have also arisen which have not been resolved.

(1) Rosette required by Chile for PR14.
(2) Academia Sinica, PRC, requires CTD and rosette - replacement.
(3) Argentina requres support for conducting XBT programmes on AX18.

How can National Agencies help

Firstly, we would like the international and national agencies who finance the operational budget for WOCE to permit WOCE to retain some small percentage of that budget (10%) as a contingency fund. This would permit WOCE to solve several problems each year at the $1-5K level. WOCE will reduce the meeting schedule of its bodies to create this surplus within a existing funding levels; however, we would not want to see the agencies then remove such funds.

Secondly, we would like to establish a network of contact points in national agencies might be able to respond to emergency requests for additional resources. We need to find out what sort of assistance various agencies might be able to provide; what sort of restrictions might apply. We need information on availability of funds for travel or training, loan of equipment, transport of equipment, etc.

GLOBAL SEA SURFACE TOPOGRAPHY MAPS FROM SATELLITE ALTIMETRY

In the September 1991 issue of the WOCE Newsletter, Allyn Clarke expressed a concern about the lack of global altimetric surfaces for WOCE modeling efforts. For the past few years our group at the Goddard Space Flight Center has been creating global maps of topography from the altimetric measurements made by Geosat during the Exact Repeat Mission from 1986 to 1989 (see also Wunsch, 1991a). We will continue to do this with altimetry data from the European Space Agency's ERS-1 satellite, launched in July 1991, and the joint U.S. and French TOPEX/POSEIDON mission, to be launched in July 1992, on a routine basis. These maps will be available for use by WOCE modelers. In the remainder of this article, the method and a few sample results are briefly described.

In our solution, the orbit and the sea surface topography are obtained through a simultaneous adjustment procedure. In this computation, the dynamic topography is estimated in terms of spherical harmonics (usually limited to degree and order 10 or 20, because of inaccuracies of the geoid at higher degrees). Our method has been described in detail by Marsh *et al.* (1990) based on some work with Seasat. Nerem *et al.* (1991) describe how this method has been adapted for use on Geosat. The surface dynamic topography is computed relative to the geoid, therefore it can be used as an absolute reference surface for estimating the deep circulation with hydrography. For Geosat we have computed maps of both the annual averaged mean surface dynamic topography, as well as monthly and seasonal maps of the topography anomaly relative to a long term mean (Nerem *et al*, 1991; Koblinsky *et al*, 1992a). Changes in topography between Geosat (1987) and Seasat (1978) have also been computed and differences compared favourably with long term changes found at some tide gauge sites (Haines, 1991).

Global scale maps of sea surface topography have been difficult to construct from the Geosat measurements because of the great uncertainty in the radial height of the satellite. A major advance in the accuracy of the Geosat orbit has been made possible in the last few years by using the altimetric range measurement (combined with a model for the geoid height and ocean topography) as a satellite tracking observation of the radial position of the spacecraft. When these observations are combined with the more traditional but much sparser OPNET and TRANET Doppler tracking data the accuracy in the radial position of the spacecraft can be reduced by more than a factor of two. This is the approach used in our solutions.

An estimate of the mean surface dynamic topography averaged over the years 1987 and 1988 is shown in Fig. 1. This surface is the sum of spherical

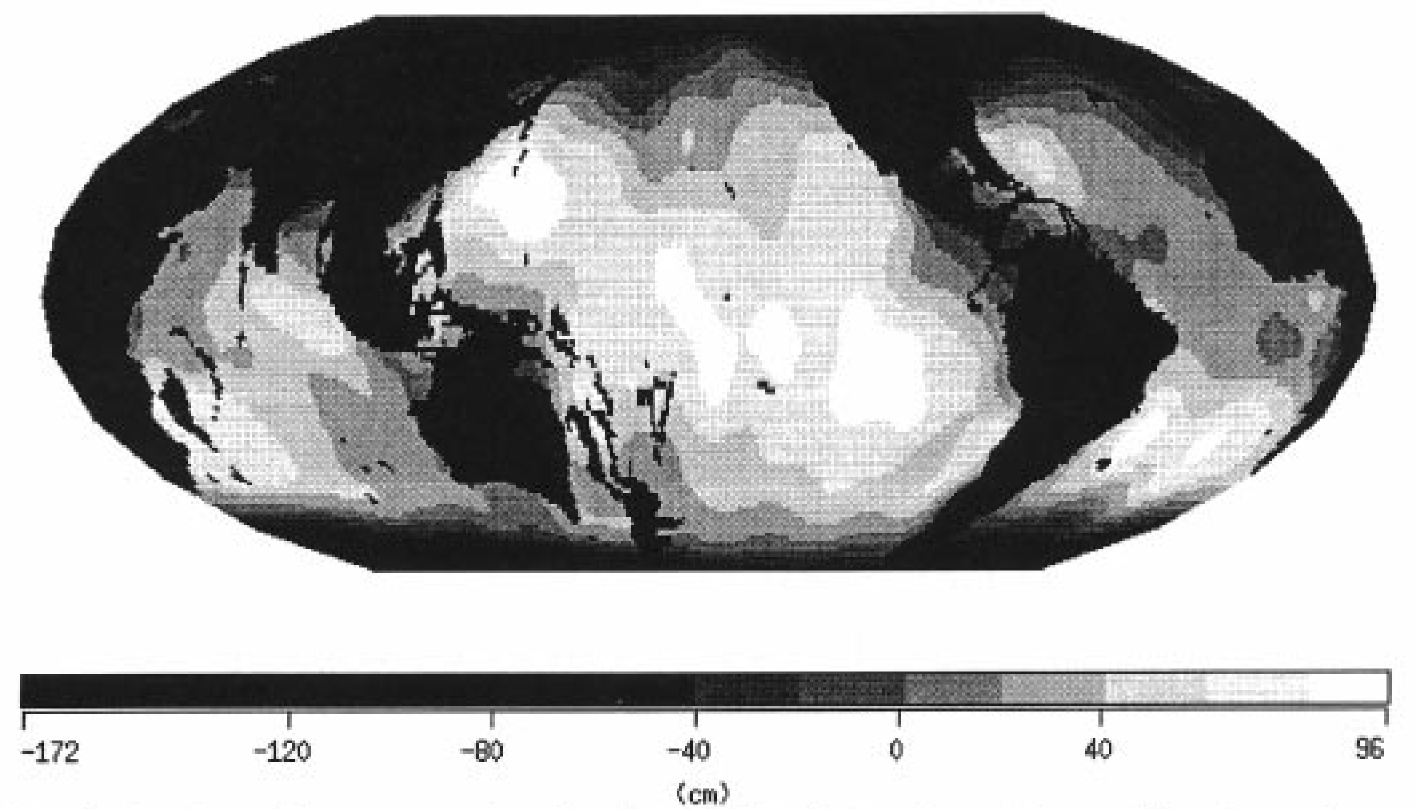


Figure 1. An estimate of the mean sea surface dynamic topography relative to the geoid computed from Geosat altimeter data for 1987 and 1988.

harmonics through degree and order 20. The formal estimate of the error in this surface computed from the estimated gravity field error covariance is about 10 cm. There are two major differences between this map and our present understanding based on in-the-water observations. First, the average topography of the southern hemisphere is higher than the northern hemisphere. This is caused by a weaker amplitude in the degree 1 and order 0 spherical harmonic. This harmonic is particularly sensitive to errors in satellite tracking station coordinates and orbit determination errors. Simulations suggest that our current estimate of this harmonic is in error because of geodetic problems (station position uncertainties and orbit error) on Geosat (Koblinsky *et al*, 1992b). These errors should be substantially reduced on TOPEX/POSEIDON. Second, the topography of the southeast Pacific is higher than the southwest Pacific. If this is an error, the most likely source is unknown systematic errors in the orbit (geographically correlated errors, see Rosborough and Tapley, 1989). Forthcoming solutions from ERS-1 and TOPEX/POSEIDON should resolve this issue because these satellites are orbiting at different inclinations and will have smaller and different patterns of geographically correlated orbit error.

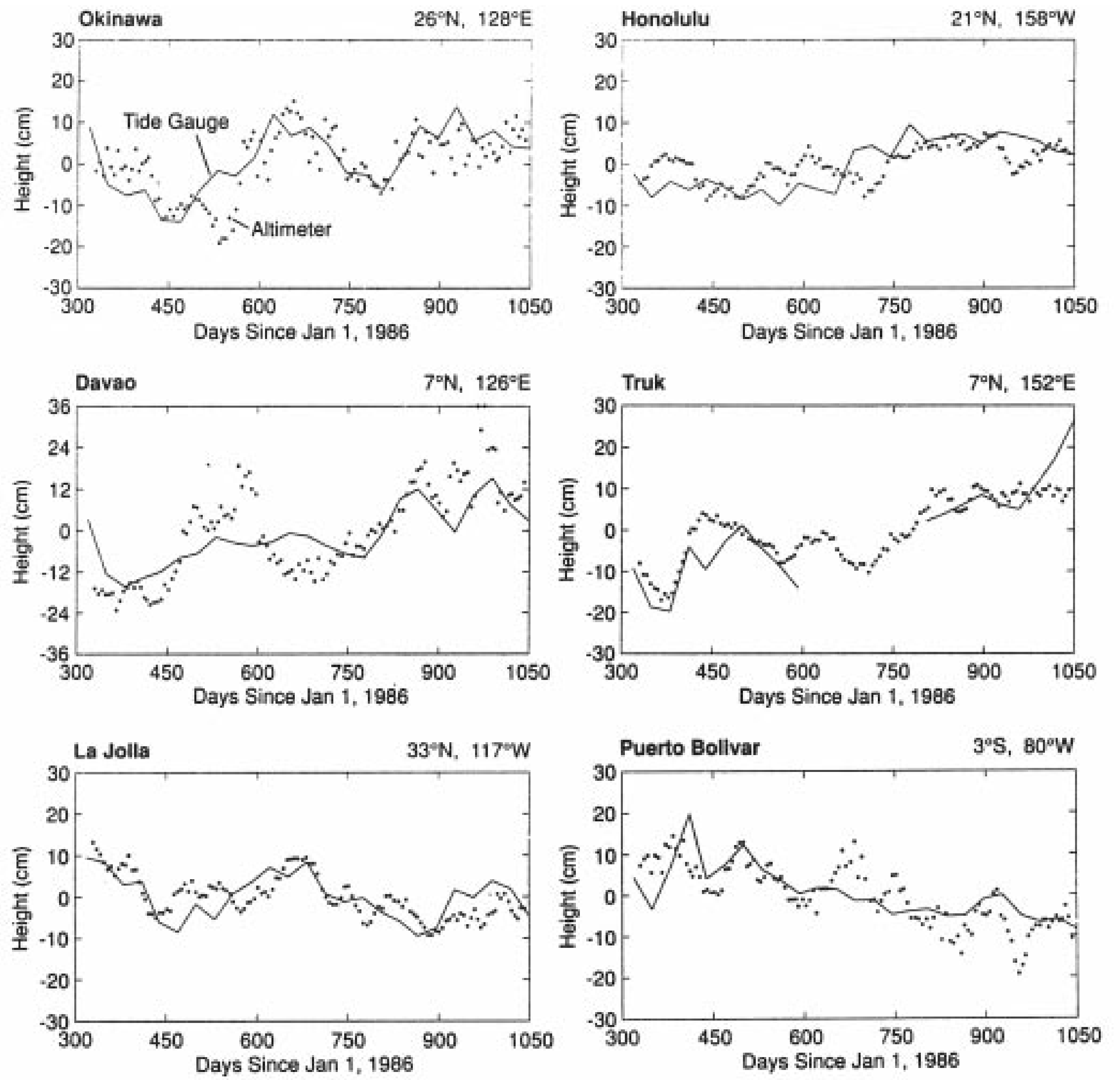


Figure 2. Comparisons between the monthly averaged altimetric and tide gauge anomaly measurements for six sites in the North Pacific. The tide gauge data are shown with the solid line. The altimeter data are shown as a series of dots. The temporal mean has been removed from both data sets.

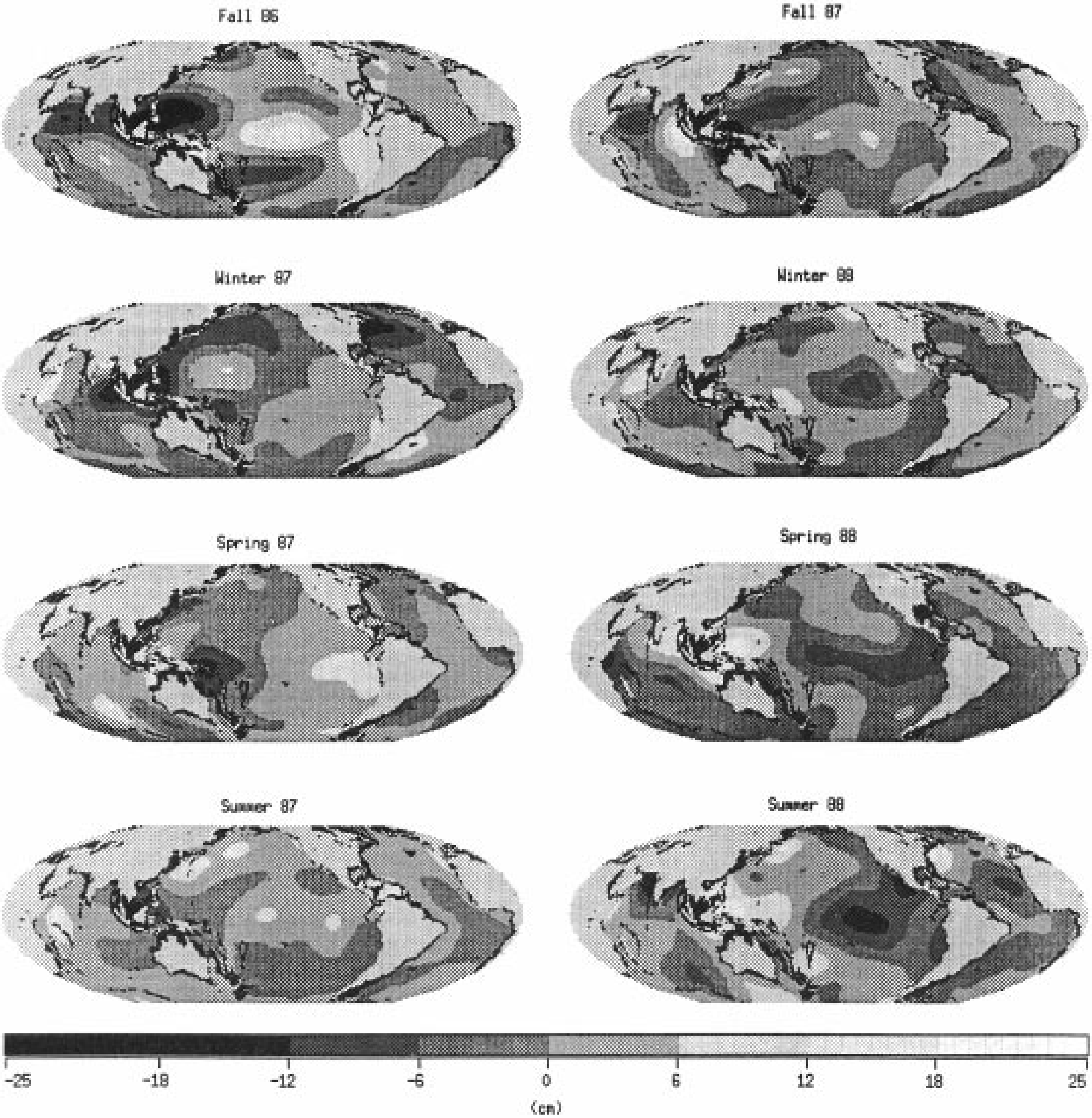


Figure 3. The ocean seasonal averages of sea surface topography relative to the two year mean value shown in Figure 1, derived from Geosat altimetry. The months of the ocean seasons are November - January for fall, February - April for winter, May - July for spring, and August - September for summer.

Estimates of the mean monthly surface dynamic topography have been made for every 6-day period between 1987 and 1989 using a sliding 30 day average over the data. The two year mean value shown in Fig. 1 was removed to create global maps of the anomaly in sea surface topography. The degree 1 and order 0 spherical harmonic has not been used in the anomaly maps because of the previously mentioned errors. Comparisons between the altimetric estimates and monthly averaged tide gauge anomaly measurements are shown for six stations in the North Pacific in Fig. 2. In general, the difference between altimeter and tide gauge over monthly averages is about 4 cm rms. Correlation between the two measurements appears to improve with increasing time scale, as might be expected because of the spatial averaging of the altimetry.

The seasonal averages of the altimeter solutions minus the mean for 1987 and 1988 are shown in Fig. 3.

These maps show how the altimetry observed the 86-87 ENSO event in the fall (November - January) of 1986. In addition, the seasonal heating cycle of the mid-latitudes is clearly evident. There is substantial changes from year to year at all latitudes. Comparisons of these topographic variations with surface temperature and winds show a high degree of correlation (see also Wunsch, 1991b), inviting further study which is underway.

In summary, efforts to derive basin and global scale maps of sea surface topography are underway. Some success has already been achieved with Geosat. Maps from ERS-1 should improve upon Geosat accuracy because of more precise tracking data and better radar range corrections. A substantial improvement in accuracy will be provided by TOPEX/POSEIDON. Our team is willing to supply examples of these surfaces to WOCE investigators interested in modeling and assimilation, in addition we are seeking a modeler to join us at Goddard to pursue the global assimilation of altimeter data.

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References

Haines, B.J. 1991. Evaluation of Seasat/Geosat orbits and altimetry with application to long term sea level changes in the North Pacific, Ph.D. Dissertation, University of Colorado, Boulder, Co., 175pp.

Koblinsky, C.J., R.S. Nerem, S.M. Klosko, and R. Williamson. 1992a Observing large scale sea surface topography from space: Part II - Evaluation. *Journal of Geophysical Research, in preparatio*n.

Koblinsky, C.J., R.S. Nerem, L.E. Braatz, T.L. Engelis, S.M. Klosko, and R.G. Williamson. 1992b. Geocenter definition in the determination of dynamic height using Geosat satellite altimetry. *Journal of Geophysical Research, in preparation.*

Marsh, J.G., C.J. Koblinsky, F.J. Lerch, S.M. Klosko, R. Williamson, J.W. Robbins, and G. Patel. 1990. Dynamic sea surface topography, gravity and improved orbit accuracies from the direct evaluation of SEASAT altimetry data. *Journal of Geophysical Research,* 95: 13,129-13,150

Nerem, R.S., C.J. Koblinsky, S.M. Klosko, and R. Williamson. 1991. Observing large scale sea surface topography from space: Part I - Techniques and Initial Results. *Journal of Geophysical Research, submitted.*

Wunsch, C. 1991a. Global-scale sea surface variability from combined altimetric and tide gauge measurements. *Journal of Geophysical Research,* 96: 15,053-15,082.

Wunsch, C. 1991b. Large-scale response of the ocean to atmospheric forcing at low frequencies. *Journal of Geophysical Research,* 96: 15,083-15,092.

TRACKING WOCE DATA

Are you wondering what type of data will be collected in the WOCE Field Programme? Where the data are being gathered? Who is the PI collecting it? What instruments will be used? Are there samples of the research results? Where will the data be archived? When and how you can get the data? It's these types of questions that the data tracking system on the Ocean Network Information Center (OCEANIC) should answer for you.

The WOCE Data Information Unit (DIU), using information from the WOCE International Project Office and the various Data Assembly Centers, has begun to track the different elements of the WOCE field programme. The most advanced plans exists for the WOCE Hydrographic Programme (WHP). As WHP plans evolve, these summaries will track the data - from inception (RFPs, proposals, proposed track lines), to projects (abstracts of funded projects), to ship time (ship cruise schedules), to data collection, availability, distribution (data directories), and research results (data products).

If you'd like to see this system for yourself, you can easily access OCEANIC in one of the following ways: through INTERNET (telnet delocn.udel.edu/username: INFO, SPAN (set host DELOCN/ username:INFO), OMNET (GOTO SONIC), and direct dial USA (302) 645-4204/ username:INFO). OCEANIC is open to the public and no password is required.

To view the tracking system maps on your terminal, your communication software must be able to emulate a Tektronics 4010 terminal. The DIU is happy to provide free emulation software for MS-DOS machines to WOCE investigators who request it.

The WOCE field programme plans are going through many revisions as the programme reaches its final form. If you see errors or omissions on OCEANIC, would like a copy of the OCEANIC Primer, or simply have questions or comments please contact us. You can reach Katherine Bouton at the University of Delaware, College of Marine Studies, 700 Pilottown Road, Lewes, DE, USA 19958, or K.BOUTON/Omnet or call her at (302) 645-4278.

AR8: SOUTHWEST ATLANTIC BOUNDARY CURRENTS

The first cruise in the WOCE Special Survey Region AR8 in the western South Atlantic took place in September 1991. Determining the extent to which variability exists in the hydrography in the AR8 region is an important WOCE Hydrographic Programmem objective. Repeated surveys in this region are required to examine interannual signals in the temperature and salinity fields. Also, water mass exchanges between the Brazil and Argentine Basin are important to the Deep Basin Experiment.

The expedition was part of the Southwest Atlantic Boundary Currents project which is headed by investigators from Servicio de Hidrografía Naval in Argentina and Fundaçao Universidade de Rio Grande, Brazil. The goal of the project is to determine the seasonal and interannual variability of the property distribution and mass transports of the Brazil Current at 32°S and at the Brazil/Malvinas Confluence near 38°S and to evaluate the strength of the cross front heat and salt fluxes due to finestructure. The planned field work includes a set of repeated hydrographic sections to be taken normal to the continental slope of South America. The initial sampling frequency is every six months but will later be increased to quarterly cruises. The programme is due to last until 1996.

The field programme began 11 September 1991 when the fisheries research vessel Capitán Oca Balda departed from Mar del Plata, Argentina. The cruise ended 17 September 1991 in Puerto Madryn, Argentina. This first cruise consisted of a single section, 350 km long (Fig. 1). Thirteen CTD stations at an average station spacing of 30 km were taken across the Malvinas Current, Malvinas Return Current and Brazil/Malvinas Confluence. Due to limitations of the hydrographic winch installed on the Capitán Oca Balda, the sampling was limited to a maximum depth of 2500 m. Two very high spatial resolution surveys were also conducted. At the shelf/slope front, 15 CTD profiles to 80 m depth were taken. At the Brazil/Malvinas Confluence, 10 CTD profiles were taken to 500 m depth. The average profile separation was 2 km. All station positions were determined with GPS.

In each hydrographic station, excluding the high resolution surveys, twelve 5 litre water samples were collected for the determination of salinity, dissolved oxygen, nitrate, silicate and phosphate. In addition, three to six reversing thermometer frames were used to determine *in situ* temperature and depth for CTD calibration.

A complementary biological sampling programme for determination of rates of filtration of zooplankton was also carried out.

Preliminary analysis of the CTD data reveals that the Brazil/Malvinas Confluence was located approximately 200 km east of the continental slope (Fig. 2). The western wall of the Brazil/Malvinas Confluence is apparent between stations 10 and 11. Subantarctic waters are found between the Brazil/Malvinas Confluence and the continental slope suggesting a strong northward penetration of the Malvinas Current. The Malvinas

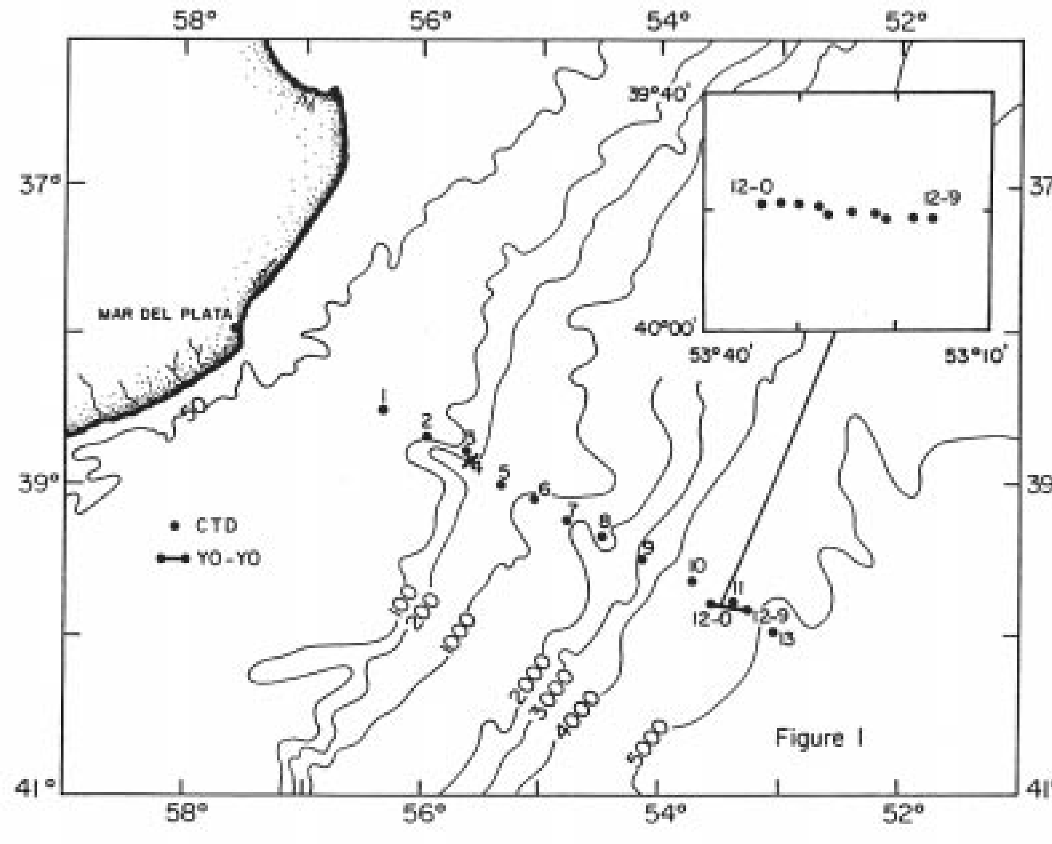

Figure 1. Location of the hydrographic stations taken during Cruise Capitán Oca Balda 05/91 (11 September through 17 September 1991), the first cruise of the Southwest Atlantic Boundary Currents Project in WOCE Atlantic Region AR8. The inset shows the station locations of the high resolution survey across the Brazil/Malvinas Confluence.

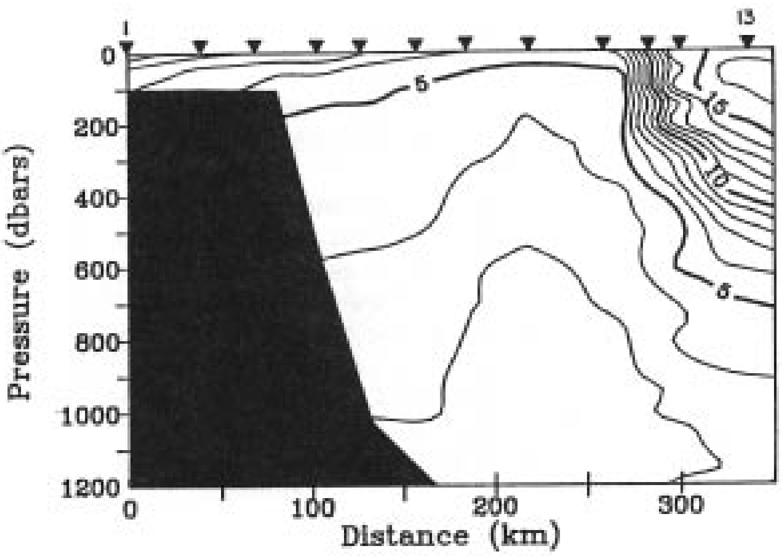

Figure 2. Upper 1200 m potential temperature section across the Brazil/Malvinas Confluence. Station positions are shown in Figure 1.

Current is evident west of station 9. Thus, with width of the northward flow is of the order of 100 km. The situation is similar to that observed in September 1989 (Piola *et al.*, 1992).

Satellite infrared images (not shown) taken from NOAA II satellite on 14 September 1991 also suggests a strong northward penetration of cold subantarctic water to 36°S. At that latitude the Malvinas Current turns eastward and returns southward immediately west of the Brazil Current marking the origin of the Brazil/Malvinas Confluence.

The high resolution sampling across the Brazil/Malvinas Confluence was taken near station 11 on 13 September 1991 (Fig. 1). The survey consisted of ten CTD profiles to 500 m depth taken along a 20 km section. CTD lowering and recovery at each site took on average 25 minutes. After each lowering the ship was repositioned using GPS to begin the next profile at a nominal separation of 2 km. Ship drift during stations due to the strong current averaged 90 cm/s to the SE. Thus, the ship manoeuvring between lowerings was crucial in keeping the section as normal as possible to the current flow. The full survey was carried out in 9 hours.

At the front, both the temperature and salinity profiles are rich in inversions and intrusions which are also evident in the temperature section. These intrusions are believed to be an indication of the cross-front property fluxes in the 10 to 100 m vertical scales (Joyce, 1977). A recent study of the cross-front mixing at the Brazil/Malvinas Confluence (Bianchi *et al.*, 1992), indicates that the region is one of the most active in the world ocean. Thus, the cross frontal fluxes at the Brazil/Malvinas Confluence may play a key role in the local heat and freshwater budgets. The high resolution survey carried out at the Brazil/Malvinas Confluence aims for a more precise quantification of the cross-frontal fluxes.

The survey reveals an extremely strong front with cross front temperature gradients as large as 3°C/km at 200 m (Fig. 3). The maximum horizontal temperature gradients are found in the 100 to 250 m depth range.

The depth of the 10°C isotherm, which marks the depth of the main thermocline, deepens from the sea surface to 300 m in 10 km. The location of the 10°C isotherm at 200 m, often taken as an indicator of the front position (Garzoli and Bianchi, 1987, Bianchi *et al.*, 1992) is at lowering 12-04.

The salinity field (not shown) is similar to the temperature field with horizontal gradients as high as 0.25 psu/km at 200 m at lowering 12-04. Small-scale temperature and salinity structures are density compensating, thus the density field (not shown) is relatively smooth.

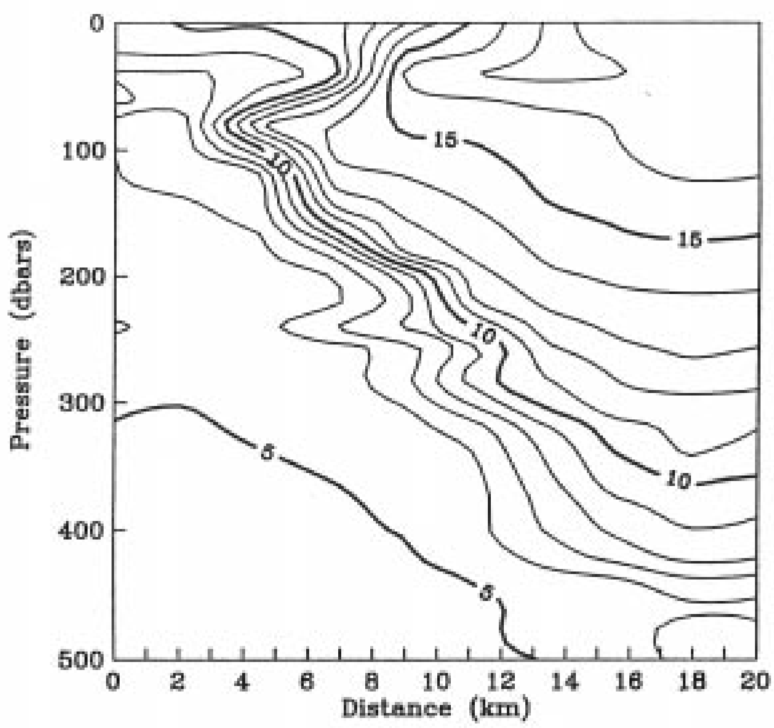

Figure 3. Very high resolution potential temperature section across the Brazil/Malvinas Confluence. Station positions are shown in the inset of Figure 1.

It is necessary to determine whether the situation described above is typical. We plan to repeat and possibly extend the high resolution surveys in future cruises. The second cruise will be carried out in late February 1992.

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References

Bianchi, A.A., C.F. Giulivi and A.R. Piola. 1992. Mixing in the Brazil/Malvinas Confluence, submitted.

Garzoli, S.L. and A.A. Bianchi. 1987. Time-space variability of the local dynamics of the Brazil-Malvinas Confluence as revealed by Inverted Echo Sounders, *Jour. Geophys. Res.*, 92, 1914-1922.

Joyce, T.M. 1977. A note on the lateral mixing of water masses, *Jour. Phys. Oceanogr.*, 7., 626-629.

Piola, A.R., A.P. Osiroff, A.A. Bianchi and M. Charo. 1992. The thermohaline structure of the Brazil/Malvinas Confluence, in preparation.

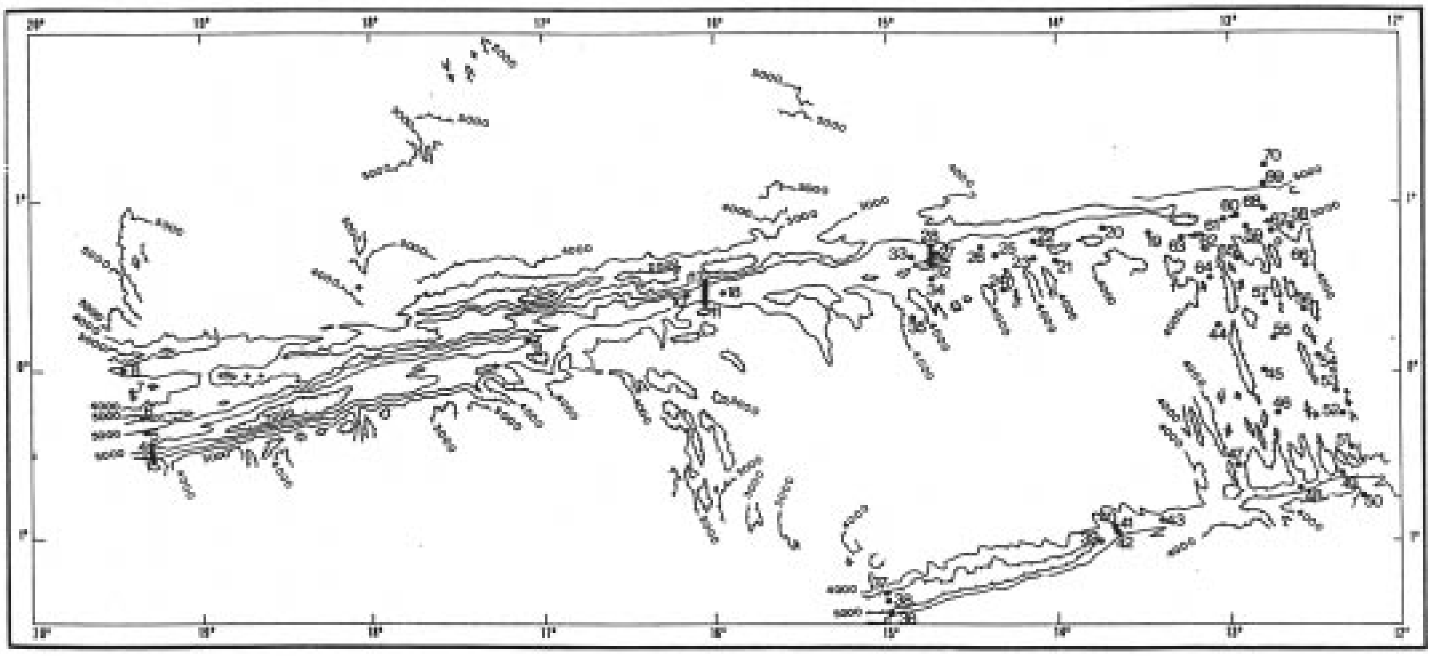
A TRIP TO THE ROMANCHE FRACTURE ZONE

The first of three planned cruises to the Romanche and Chain Fracture Zones took place from 10 August to 7 September 1991. The goal of the first cruise was to occupy a network of hydrographic stations to show the path that bottom water takes through the fracture zone and its evolution along the way. To do these, detailed bathymetric information was crucial, and many stations were placed based on expected pathways according to a multibeam survey of bathymetry obtained during the cruise.

Beginning and ending in Dakar, Senegal, the first cruise of the “Romanche” experiment was only among the first research cruises of the new French research vessel l’Atalante. By using a CTD (N.B. Mk III) together with water sampling, and the ship’s multibeam bathymetric surveying equipment (SIMRAD) we hoped to track the path of Antarctic Bottom Water as it flows through the fracture zones. Another purpose was to furnish the necessary information to place the planned current meter arrays: one in each fracture zone consisting of four moorings each. These arrays will be deployed during the second cruise of “Romanche”, scheduled for December 1992, and are due back two years later. These direct measurements are necessary to determine the transport of the bottom water, since the fracture zones are located within a couple of degrees of the equator and reliable geostrophic estimates form hydrography are not possible from a few surveys. Finally, in addition to the path and transport of the bottom water, particular attention will be paid to the evolution of tracer characteristics along the path, to quantify the amount of mixing which occurs in the fracture zone and compare this to that which occurs in surrounding basins.

This programme was proposed in the framework of the Deep Basin Experiment (DBE), itself a part of the World Ocean Circulation Experiment. The DBE came together because it was thought important to measure the mass sources and sinks to a single basin, as well as the flow within, to make progress in understanding the dynamics. The Brazil Basin was chosen because of its relatively simple geometry and also because of the superposition of several interesting water masss of very different origin. Antarctic Bottom Water enters the Brazil Basin in the south through the Vema Channel and Hunter Channel; it exits to the northwest across the equator into the Ceara Abyssal Plain and also eastward along the equator through the Romanche and Chain Fracture Zones. All of these entrance and exit points are the subject of experimental programmes including hydrography and current meter arrays. North Atlantic Deep Water flows south along the western boundary feeding and receiving zonal flow at the equator and possibly several other latitudes as well. The interior of the basin will, in addition to current meter and hydrography work, be peppered with floats at a variety of levels associated with the major water masses. The idea is that enough independent pieces of information will be brought together to constrain models of interior and boundary dynamics.

The strategy used during Romanche I was to a great extent exploratory since the path bottom water takes depends crucially on the details of the seafloor. Thus, the first component of our study was to choose subregions which include all possible pathways and map these with the multibeam sounder. This is easy when the fracture is well-defined with steep walls, but becomes more difficult where the fracture begins to blend in to the background topography of the Mid-Atlantic Ridge (at either end of the fracture). Next, hydrographic stations were placed according to the depth information along possible routes. Neither method alone is capable of finding the path. The seafloor is too complex to interpret CTD stations



Topography of the Romanche (upper) and Chain (lower) Fracture Zones, isobaths every 1000 m, including the positions of hydrographic stations. After Monti, S. and H. Mercier (1991): Carte Bathymetrique de la Zone de Fracture Romanche, IFREMER, DRO and LOP, 29280 Plouzane, France. The narrowest gap along the Romanche Fracture Zone is located at Station 10, the 4350 m deep main sill is located between Stations 27-33. Stations 19-26 mark alternately downstream sills and basins.

occupied “blindly”, and the bathymetry by itself can be ambiguous.

Altogether 2200 nm of steaming were done, enough to cover the Romanche Fracture Zone between 19°W and 12°W, the eastern part of the Chain Fracture Zone, and the axial valley in between. Credit must be given to the SIMRAD system for reliably measuring depth across a band typically 120 nm wide, a great help towards accomplishing the goals of the experiment. The data from this cruise and several others has been combined into a map of the zone (Fig. 1).

Seventy CTD stations were occupied during the cruise, all to within 15 m of the bottom. At each station between 16 and 32 levels were sampled for salinity, dissolved oxygen, silica, nitrate, and phosphate. Freons were measured at 39 stations. First results show clearly the strong mixing between bottom water and Lower North Atlantic Deep Water across a complex system of sills and basins along the primary bottom water pathway in the Romanche Fracture Zone.

The scientific party aboard included M. Arhan, A. Billant, P. Branellec, N. Daniault, J.-P. Girardot, J.-P. Gouillon, J. Kervella, H. Mercier (chief scientist) of the Laboratoire de Physique des Oceans (Brest); Del Amo, J.-F. Maquer, P. Morin of the Laboratoire du Chemie Marine (Brest); L. Memery of the Laboratoire d’Oceanographie et de Dynamique du Climat (Paris); M.-J. Messias of the Centre d’Etude Nucleaire (Saclay); K. Speer of the Institut für Meereskunde (Kiel); J. Honnerez, E.-H. Talbi of the Institut de Geologie de Strasbourg; C. Thomas of the Groupe de Recherche en Geodesie Spatiale (Toulouse); E. Braga of the University of Sao Paulo (Brazil); B. Bourles and Y. Gourion of ORSTOM. Thanks also to the crew of the N.O. l’Atalante. Funding comes from IFREMER and INSU. Participation of KGS was supported by the BMFT.

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COMPILING THE PRE-WOCE TRACER DATA

During WOCE there will be (in addition to the hydrographic programme, satellite missions, direct current measurements and many other activities) a global tracer survey which hopefully will result in an adequate description of the global distributions of oceanic tracers during the 1990's. Among the most important tracers are the chlorofluorocarbons (freons), tritium, helium-3 (^3He), and carbon-14 (^{14}C), but others will be measured as well. The tracer data complement the hydrographic data, and it is anticipated that they provide independent information and will help in determining flow rates and mixing coefficients in the ocean.

However, the full potential of the new tracer data will only be exploited when they are combined with the existing (pre-WOCE) historical tracer data. These historical tracer data are important for the early stages of the anthropogenic tracers in the ocean. They contain information which we cannot obtain today and which will not be found in the WOCE tracer data because of the transient nature of the distributions. For tritium and ^{14}C, measurements during the 1960's and 1970's are important because maximal input of tracer from the atmosphere occurred during these periods, and the tracer distributions then exhibited large spatial and temporal gradients. Pre-bomb-^{14}C data are indispensable for the estimation of natural ^{14}C background concentrations and the separation of the bomb-^{14}C contributions, and early freon data provide a better knowledge of the rate of temporal increase of freons in the ocean.

With the perception of the relative importance of the "old" tracer data and with the realization that these data so far only exist in many small pieces in many different places and are not readily available as a whole, an effort was started to try to put together the many pieces and produce a global, pre-WOCE tracer collection. Once completed, the data collection will be available to a broad group of interested scientists in the WOCE community. It is hoped that existence of this dataset will facilitate and promote the use of tracers for water mass analysis, circulation studies and numerical ocean models.

All known-of tracer groups have been approached and asked to contribute their "old" tracer data. Response has been mixed, reaching from strong support to no response at all. At present the pre-WOCE tracer collection contains 1083 stations (Fig. 1). Highest station density is in the North Atlantic, but due to GEOSECS, INDIGO and several Meteor cruises the Pacific, Indian Ocean and the Mediterranean are also represented. A relatively large amount of tritium and ^{14}C data from the early 1960's, which are only available in printed form, are waiting to be typed in, and other (newer) datasets are still expected to arrive.

The data set includes the following tracers: freons (CFC-11 and CFC-12), tritium, helium (^3He and ^4He), and carbon-14. In addition, the corresponding hydrographic, oxygen, nutrient, CO_2 and T-Alk data are also recorded. This relatively large suite of oceanographic parameters was chosen to allow and to encourage studies

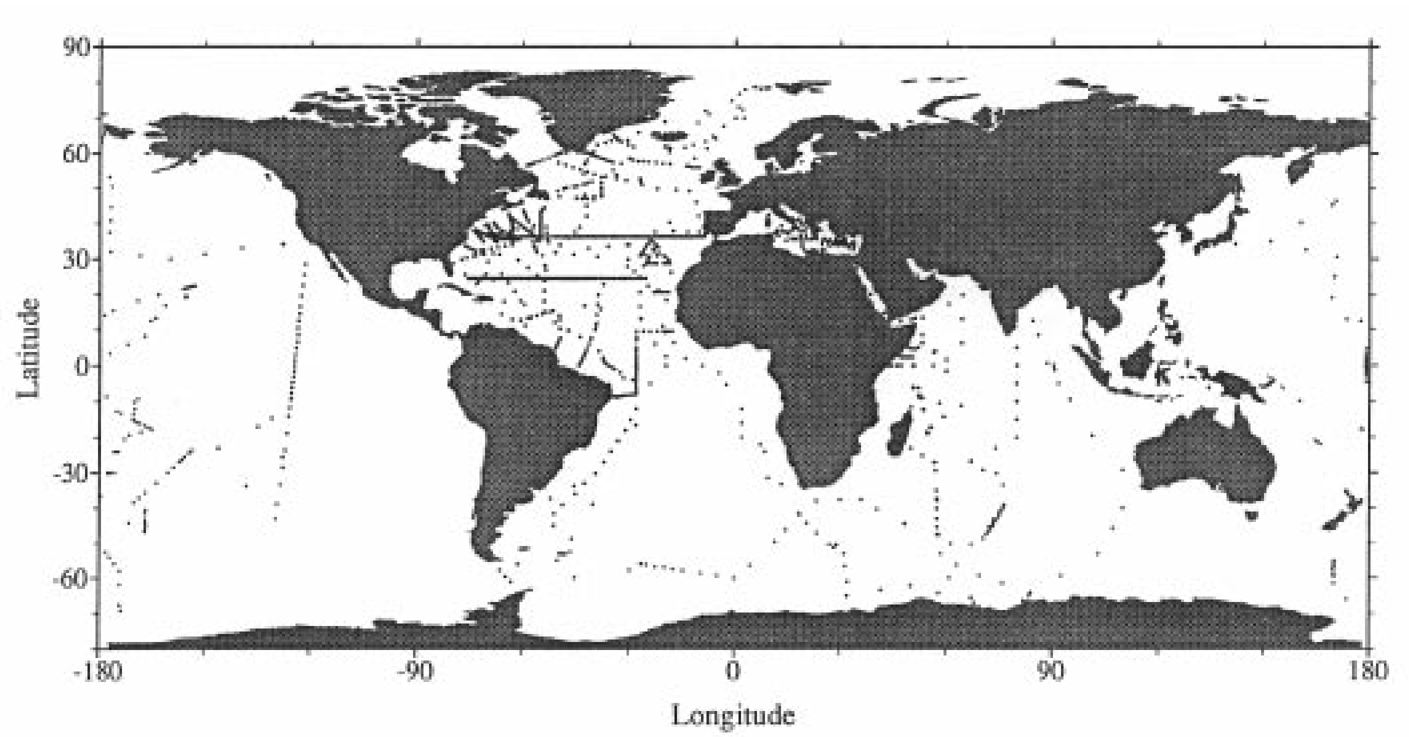

Figure 1. Station map of pre-WOCE tracer dataset (November 1991)

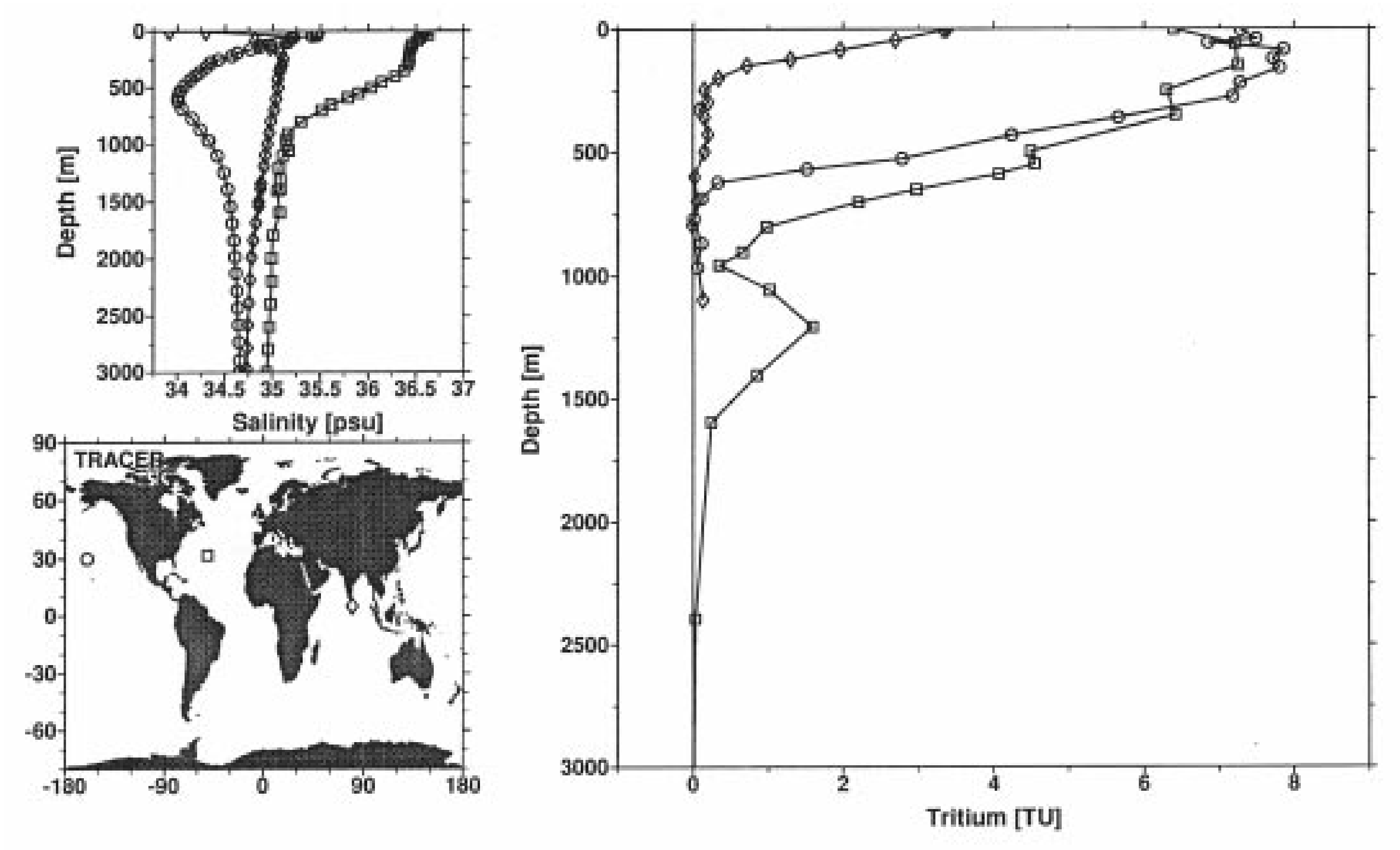

Figure 2. Example hardcopy output from program COLSHO

that combine tracers with hydrography and other types of data. Investigations of the biological and oceanic carbon cycles in the context of tracer data are possible, and multi-parameter water mass analysis becomes an easy task.

It is intended to distribute the pre-WOCE tracer data on request in two different formats. There will be a plain ASCII version of the data which is highly portable and can be installed on all computers. In this case, the user will be responsible to write his/her own software for reading and processing of the data. Alternatively, the same data will be provided in a compact and easily accessible format on MS-DOS PC's. Together with this version of the data comes a program (COLSHO) for easy selection and graphical display of the data on the screen as well as on paper and transparency hardcopy.

The program allows selection of stations through a variety of criteria and lets you plot the data of one or more selected stations in one or more property/property plot-windows which are displayed simultaneously. The user can easily modify the graphics layout and may zoom into any of the windows. An example of output from COLSHO is shown in Fig. 2. Emphasis is on ease of use, and even computer novices should quickly be able to produce hardcopy output of the data.

Although ultimately the complete pre-WOCE tracer collection will be available to a wide community, during the build-up phase it will be released only to those scientists who have already contributed. We believe that the tracer community as a whole will benefit from a more extensive use of tracer data in oceanography, and would like to ask scientists who are still hesitating to co-operate in this effort. We are grateful to those researchers who have already submitted their data.

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AR16 AND AR6: WOCE - EASTERN BOUNDARY CURRENT TRANSPORT STUDY

This study is aimed at estimating transport (and its variability in space and time) in the northeastern Atlantic area depicted by Fig. 1. Characteristic features to be investigated are the Portugal/Canary Current and "Shelf counter currents" in the upper levels, intermediate (poleward) slope currents and the deeper Mediterranean Outflow.

Net transport balances are going to be measured directly by current meter moorings and stepwise current profiling and indirectly from geostrophic calculations in order to compare actual conditions with historical data. The deviations from mean conditions (historical data) should allow a better understanding of the fluctuation range, which should be represented in basin-scale models. A further major objective is the investigation of the regional eastern boundary current system along the continental slope and its contribution to the transport balance.

From a total of five proposed cruises by German research vessels, three have been successfully completed (Heincke, 19 March - 20 April; Alexander V. Humboldt, 20 August - 25 October; Heincke, 15-23 October; all 1991). Fig. 1 shows only those activities already realized. Eight current meter moorings have been deployed to elucidate the signal-noise ratio in the Eastern Boundary Currents. CTD-profiles (often with dissolved oxygen) have been taken from the surface generally to the bottom-layer with *in situ* calibration of T, C, P and O. The completion of data processing from these cruises is anticipated by November 1992.

The study is part of the German WOCE-contribution and conducted and basically financed by the Institut für Meereskunde Warnemünde (IfMW), which will be changed to the Institut für Ostseeforschung on 1 January 1992, Bundesamt für Seeschiffahrt und Hydrographie Hamburg (BSH) and Biologische Anstalt Helgoland (BAH). Financial support was also obtained from the German "Bundesministerium für Forschung und Technologie" since October 1991. To achieve wider spatial scales, there is close co-operation with the Institute for Remote Sensing Application of the European Community at Ispra (IRSA), Mullard Space Science Laboratory, London (MSSL), and Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven (AWI) to incorporate satellite data. In this context ,radiometer calibration work for the European Remote Sensing Satellite (ERS-1) was done (Heimann KT4, 10 - 12 µm) for the skin-bulk-SST relationship, and 56 radio-sondes launched at satellite overpass times to check atmospheric correction procedures during August till October 1992. For this purpose, IRSA provided additional funding. The study expands partly an existing co-operation between BAH and the University of Lisbon and aims at future co-operation with Morocco.

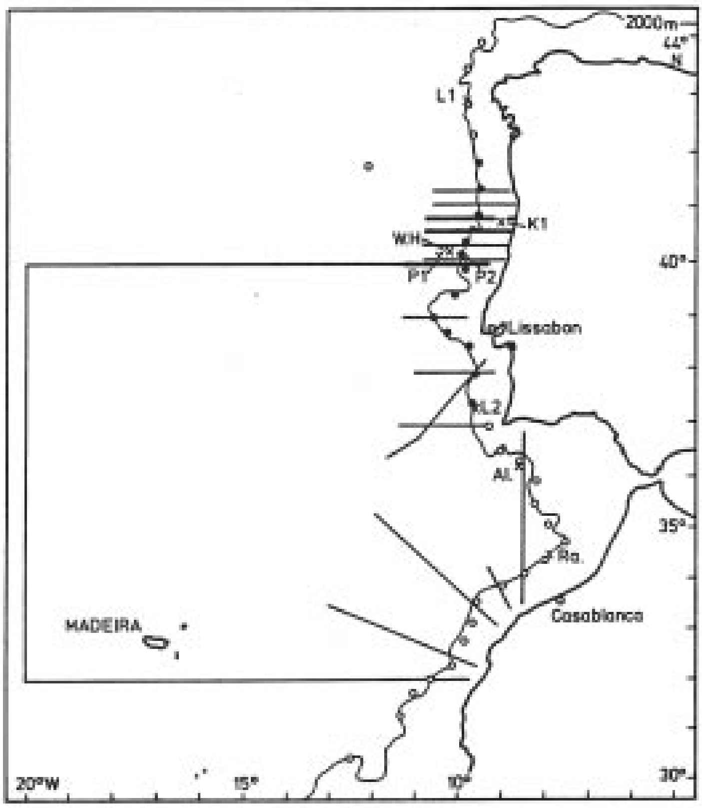

Figure 1. Mooring positions are denoted by crosses. K1 is a short term mooring (2 weeks), all other are long term moorings ≥10 months. Lines represent CTD-sections (spacing 5-10 n.m. above the shelf, 8-30 n.m. offshore. Open circles show CTD stations along the 2000 m isobath. Solid dots or lines indicate where stations have already been repeated two to three times.

Two further cruises are scheduled for January-February 1992 (Heincke) and August-October 1992 (Alexander V. Humboldt) in order to obtain repeated measurements at several transects and to deploy additional moorings off Morocco.

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R/V VITYAZ 18, R/V PROFESSOR SHTOCKMAN 26, R/V ACADEMICIAN KURCHATOV 50 CRUISES, APRIL-JUNE 1990

The research on the Atlantex-90 programme were carried out by the P.P. Shirshov Institute of Oceanology on three ships. The main objective of the expedition was to study the Gulf Stream delta structure and temporal variability during the three month period. (Delta refers to the Gulf Stream region SE of the Grand Banks.)

Sixteen moorings with temperature and current meters were set for a period of one month. In April, R/V Vityaz and Professor Shtockman made CTD casts on the circuit around the area of the Gulf Stream delta and beginning of the North Atlantic current with 30-mile spacing between stations. The station positions are shown in Fig. 1. The majority of the casts were made to depths of 2000 m.

In May, R/V Vityaz and Professor Shtockman carried out an eddy resolving survey in the delta area. In June the stations on the circuit were repeated. The second survey of the Gulf Stream delta area was carried out in June by R/V Vityaz and Professor Shtockman while R/V Academician Kurchatov set the moorings to the north in the North Atlantic current.

The temporal variability of the jet structures was studied during the three month period. The jet patterns are shown in Fig. 1 and the figures indicate the values of water transport in each stream. In April, the Gulf Stream and the Slope water current formed a joint stream which separated into two in May due to the Gulf Stream displacement to the south. An intensive meander formed in the delta area. In June this meander separated from the stream forming an intensive cold ring (Fig. 2).

The total amount of the water transport in the Gulf Stream did not vary greatly during the period of three months. The transport was calculated relative to the 2000 db reference level. At the same time there was a

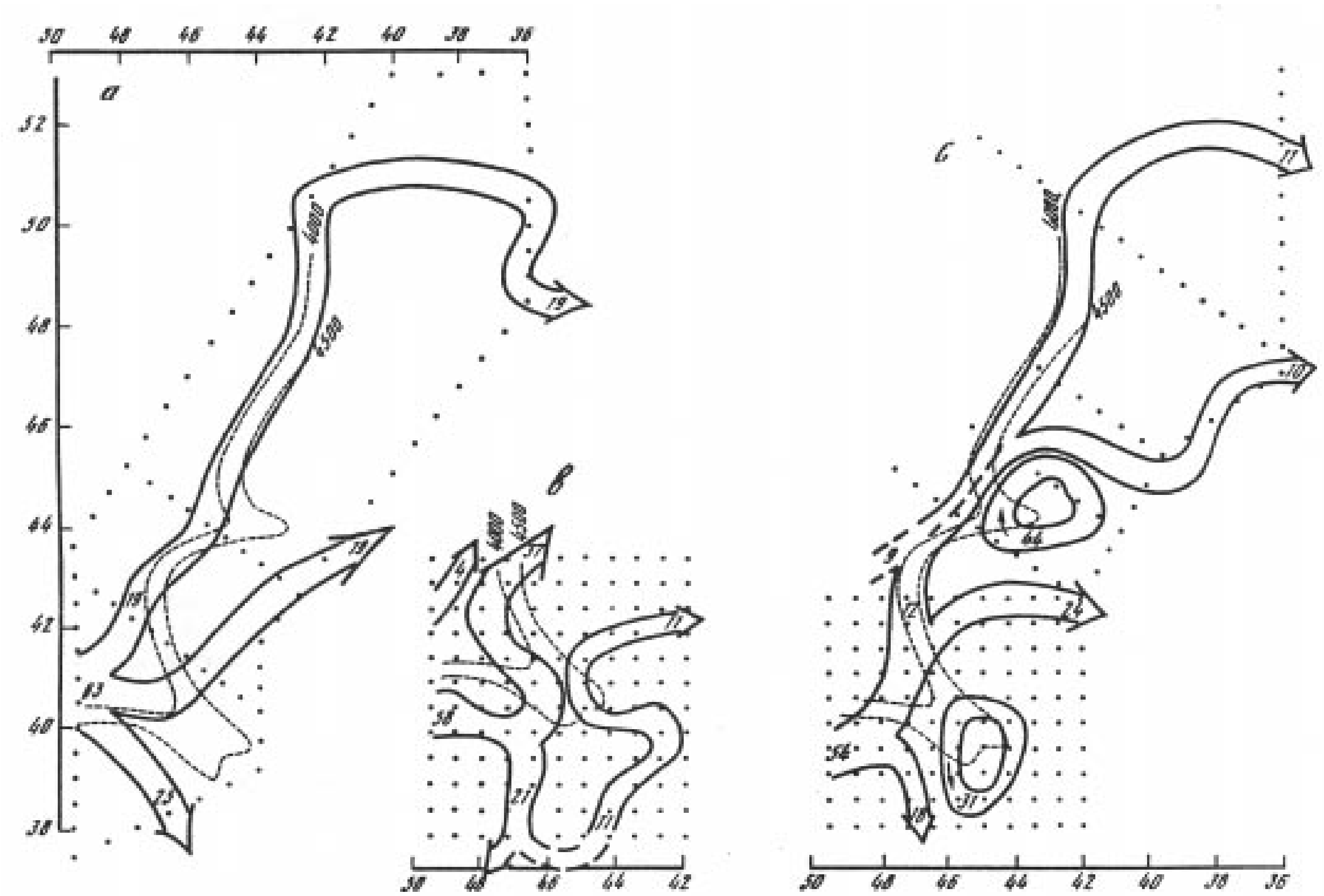

Figure 1. The jet currents scheme by measurements during the three surveys: (a) April 10-22; (b) May 5-22; (c) May 28-June 13. The dots mark the station positions. The dashed lines - 4000 and 4500 m isobaths. The figures in the jets show the water transport in Sverdrups.

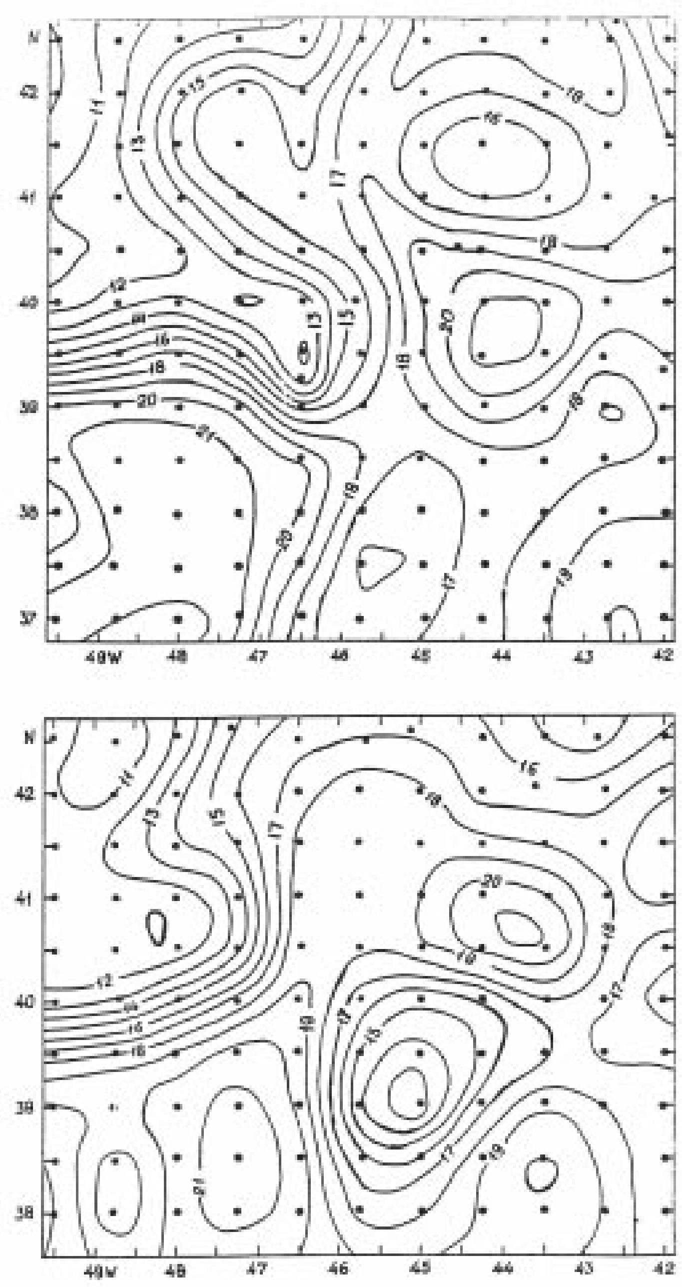

Figure 2. Dynamic topography of the sea surface in dynamic decimeters referred to the 2000 decibar surface during the surveys in May (above) and June (below). Station positions are indicated by dots.

significant transport change in the resulting jets after the Gulf Stream termination. This fact is possibly due to the variation of the barotropic joint transport of the Gulf Stream and Slope water currents. A comparison of velocity measurements obtained using current meters on moored buoys along 36°W in the North Atlantic current with calculations made by the dynamic topography, gave an estimate that the barotropic part of the water transport is about 60% of the total transport. The ring separation from the jet current was registered by the two eddy resolving surveys. The newly born ring had horizontal dimensions 300-220 km at 500 m depth. The isopycnal displacement was 800 m in the main thermocline. The Θ-S properties of the sea water in the centre of the ring were typical for the subpolar region whereas the surrounding waters were of the subtropical type. Cyclonic and anticyclonic eddies were found in the area to the south of the front. They were generated possibly by the instability of the Gulf Stream continuation jets. Those eddies observed in this area did not contain water differing from the surrounding.

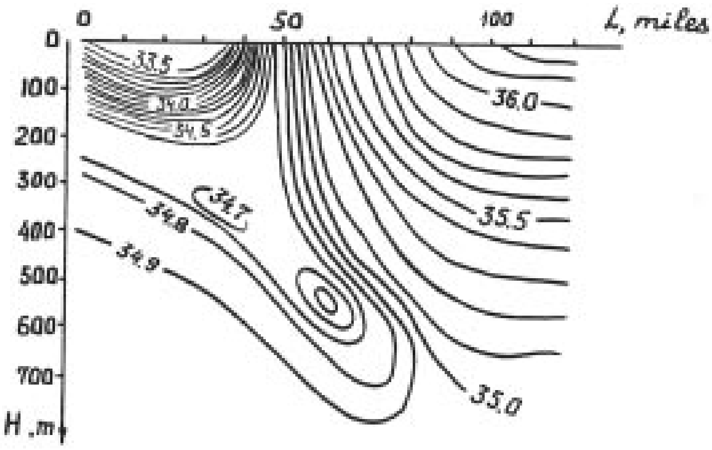

Figure 3. Salinity cross-section from 42°43'N, 48°55'W to 41°36'N, 46°41'W across the North Atlantic current showing an intensive intrusion of cold low salinity waters.

Some more measurements were made during the expedition. The structure of the frontal zone was studied with the help of towed CTD in the scanning regime. Some intensive intrusions were registered. Intrusions of cold, relatively fresh water from the surface layers originating from the areas to the north of the front were observed to penetrate along isopycnal surfaces to deep layers on the warm side of the current. These intrusions could be more than 100 m thick. They were in the shape of tongues deepening perpendicular to the front directions (Fig. 3).

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WOCE CALENDAR

Fifth WOCE SSG Executive Meeting, EXEC-5
2 March 1992, Paris, France
Contact: WOCE.IPO

Second Intergovernmental WOCE Panel Meeting, IWP-2
3-4 March 1992, Paris, France
Contact: WOCE.IPO/IOC.SECRETARIAT

Fifth WOCE Core Project 3 Working Group Meeting, CP3-5
1-3 April 1992, Wormley, UK
Contact: WOCE.IPO/IOS.WORMLEY (W.J. Gould)

Fifth WOCE/TOGA Surface Velocity Programme Planning Committee Meeting, SVP-5
6-8 April 1992, Bermuda
Contact: WOCE.IPO/P.NIILER

Fifth WOCE Core Project 2 Working Group Meeting, CP2-5
13-16 April 1992, La Jolla, USA
Contact: WOCE.IPO/A.GORDON

WOCE North Pacific Workshop
27-28 April 1992, Vancouver, Canada
Contact: WOCE.IPO/P.LEBLOND

Fifth WOCE Core Project 1 Working Group Meeting, CP1-5
29 April-1 May 1992, Vancouver, Canada
Contact: WOCE.IPO/L.TALLEY/P.LEBLOND

WOCE Upper Ocean Thermal Data Assembly Centre Coordination Meeting
May/June 1992
Contact: WOCE.IPO

Numerical Experimentation Group/Core Project 1 Joint Workshop
and Seventh WOCE Numerical Experimentation Group Meeting (NEG-7)
1-4 September 1992, Devizes, UK
Contact: WOCE.IPO/IOS.WORMLEY (D.J. Webb)

Sixth WOCE SSG Executive Meeting, EXEC-6
September 1992
Contact: WOCE.IPO

Second TOGA/WOCE XBT Programme Planning Committee Meeting (TWXXPPC-2)
20-22 October 1992, Geneva, Switzerland
Contact: WOCE.IPO/INTL.TOGA

Fifth WOCE Data Management Committee Meeting (DMC-5)
October/November 1992
Contact: WOCE.IPO

Nineteenth WOCE SSG Meeting, WOCE-19
February 1993, Southampton, UK
Contact: WOCE.IPO

WOCE is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of WOCE is under the guidance of the JSC/CCCO Scientific Steering Group for WOCE, assisted by the WOCE International Project Office. JSC and CCCO are the main bodies of WMO-ICSU and IOC-SCOR, respectively, formulating overall WCRP scientific concepts.

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Contributions should not be cited without the agreement of the author.

We hope that colleagues will see this Newsletter as a means of reporting work in progress related to the Goals of WOCE as described in the Scientific Plan. The SSG will use it also to report progress of working groups, and of experiment design and of models.

The editor will be pleased to send copies of the Newsletter to institutes and research scientists with an interest in WOCE or related research.